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DITCHING TESTS OF A 1/8-SIZE MODEL OF THE

NAVY SB2C-1 AIRPLANE (ARMY A-25) IN

LANGLEY TANK NO. 2 AND ON AN

OUTDOOR CATAPULT

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WASHINGTON

NACA LANGLEY MEMORIAL AERONAUTICAL LABORATORY

MEMORANDUM REPORT

for the

Bureau of Aeronautics, Navy Department

MR No. L5L07

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SUMMARY

Tests were made to determine the best way to land the SB2C-1 airplane in calm and rough water and to determine its probable ditching performance. A 1/8-size dynamically similar model of the SB2C-1 airplane was ditched in Langley tank no. 2 and in calm and rough water at the outdoor catapult. The behavior of the model was determined by making visual observations by recording the maximum longitudinal decelerations and by taking motion pictures of the ditchings.

The following conclusions were drawn from the results of the tests:

1. The airplane should be ditched in a normal tail-down landing attitude (thrust line at 15°) with the flaps half down.

2. In rough water, ditchings should be made along the wave crests when feasible. If a strong cross wind exists, it may be necessary to land across the waves and, in such a case, an attempt should be made to have the tail of the airplane touch the windward side of a wave.

3. If the bomb-bay doors do not fail, skipping will probably occur, but if the bomb-bay doors do fail, an event which probably will occur in the full-scale airplane, a dive may result.

4. If one wing tip digs into the water, a violent turn may result.

5. The arresting gear hook should not be extended in ditching.

6. A slight improvement in the ditching behavior is obtained when the tail wheel is retracted.

INTRODUCTION

Tests were conducted in the Langley tank no. 2 and on an outdoor catapult in order to determine the best way to land the SB2C-1 airplane in calm and rough water and to determine its probable ditching behavior. These tests were requested by the Bureau of Aeronautics, Navy Department, on July 2, 1943.

PROCEDURE

Description of model.- A 1/8-size dynamic model of the SB2C-1, shown in figure 1, was used in the tests. The type of construction used in building the model was similar to that described in reference 1. The model had a wing span of 6.2 feet and an over-all length of 4.57 feet. The scale weight of the model was determined from the following relationship:

Weight of model = Weight of full-scale airplane

$$\times \text{(scale of model)}^3$$

In order to obtain scale strength flaps, an aluminum bracket was attached to each flap at its midspan and another bracket was attached to the wing directly in front of the bracket on each flap. The arrangement of these brackets is shown in figure 2. String was fastened around the brackets in such a manner as to hold the flaps in position. When the scale load which would cause failure of the flaps on the airplane (505 lb/sq ft, given in a letter from the Curtiss-Wright Corporation) was applied to the flaps, the string of known strength would break allowing the flaps to retract.

Test Methods and Equipment

Tank tests.- When the model had been statically balanced, it was attached to the aerodynamic gear that is located at the rear of the towing carriage in Langley tank no. 2. The aerodynamic gear permits the model to roll, yaw, or pitch without restraint (fig. 3). With the model supported at the center of gravity the model was towed through the air at the various scale speeds at which it was to be ditched. These speeds were obtained by using Froude's Law of Similitude,

Speed of model = Speed of full-scale airplane

$$\times \sqrt{\text{scale of model}}$$

Movable tabs were adjusted to balance the model aerodynamically in roll and yaw. The elevator settings required to trim the model in pitch for each of the attitudes and conditions of simulated damage were determined.

The aerodynamic gear was replaced by the launching gear which is arranged so that the model can be set at various attitudes and heights above the water. After the elevators on the model were adjusted for the condition to be tested, the model was attached to the launching gear as shown in figure 4. When the model was to be ditched, the towing carriage was run at a constant speed and the model was released from the front and rear suspension hooks simultaneously. The model glided into the water at approximately the attitude at which it was released. Each ditching occurred at about the same location in the tank.

Two observers at the ditching station determined the length of run and noted the behavior of the model. A photographer took 16-millimeter motion pictures, at approximately 64 frames per second, of all the ditchings. The attitude of the model at contact with the water and its vertical speed were determined for a few representative ditchings by measurements from the motion pictures.

Maximum longitudinal decelerations and time-history records of the decelerations were obtained with small accelerometers that were placed in the model as close to the pilot's cockpit as possible.

With the launching gear at the rear of the towing
carriage, it was found that the air flow is such that it
gives the effect of a slight head wind. Since no power
is provided in the models, the aerodynamic lift at speeds
corresponding to power-on landings tends to be less than
the correct value. With the model located at the rear
of the carriage, some of the lift increment that would
result from the use of power is obtained. This addi-
tional lift probably enables a more accurate simulation
of power-on landings with the model. However, in the
tank, at speeds corresponding to power-off landings,
the lift from the aerodynamic surfaces of the SB2C-1 model
tended to be too great at speeds above 46.7 feet per
second (78.2 knots full scale). Spoilers as shown in
figure 5 were added to the wings for the tests at speeds
above this value to reduce the lift to the proper amount.

When the flaps were deflected, the elevator control
of the model was insufficient to cause the model to
maintain the desired attitudes, so an auxiliary elevator
surface made of 1/16-inch aluminum was mounted on the
rudder as shown in figure 6.

Catapult tests.- The test methods used at the outdoor
catapult are given in reference 1.

Test Conditions

(All values given refer to the full-scale airplane.)

Gross weight.- The gross weights of the airplane
used in the tests were: maximum overload, 15,704 pounds;
normal gross load, 13,060 pounds; scout condition, less
entire expendable load, 11,090 pounds.

Location of center of gravity.- A center-of-gravity
position of 30.2 percent of the mean aerodynamic chord
and 1.2 inches below the thrust line was used in the
tests.

Attitude of thrust line.- Three attitudes were used
in the tests: 15° near stall, 8° medium attitude, and
2° approximate attitude at cruising speed.

Landing gear.- The landing gear was retracted in
all of the tests.

Flaps.- The flap settings used in the tests were:
full up, half down (30°), and full down (60°).

Landing speed.- The landing speeds may vary con-
siderably, depending on the conditions of wind, power,
flaps, and attitude. A range of landing speeds covering
a reasonable variation in wind, power, and flap setting
was used. (See table I.) The catapult tests were made
at the normal-weight power-off condition only. The
speeds were computed from data furnished by the Curtiss-
Wright Corporation and are given in the following
table:

Attitude of thrust line (deg) / Flaps	15	8	2
Full up	84.3 knots 97 mph	113 knots 130 mph	
Full down	70.4 knots 81 mph	85.5 knots 96 mph	104.3 knots 120 mph

Conditions of simulated damage.- From inspection of
the actual airplane it was concluded that the bomb-
sight doors will collapse upon contact with the water,
for these doors fold inward at the center and can be
moved upward by pushing hard with one's hand. It was
therefore assumed that the bomb-sight doors would fail
in every ditching. The following are the conditions
of simulated damage used in the tests:

(a) Bomb-sight doors removed (fig. 7(a)).

(b) Bomb-sight doors and bomb-lever doors removed
(fig. 7(b)).

(c) Bomb-sight doors, bomb-lever doors, and bomb-
bay doors removed (fig. 7(c)).

As the ditching behavior in the tank for damage
conditions(a) and (b) was practically identical, only
conditions (a) and (c) were tested at the outdoor
catapult.

Tail wheel.- In some versions of the SB2C-1 airplane
the tail wheel is retractable. The tail wheel and the
fairing of the oleo gear were placed on the model as
shown in figures 2 and 8 to represent the version with a
nonretractable tail wheel. Retraction of the tail wheel
was simulated by removing this unit. Tank tests were made
both with and without the tail wheel attached. Catapult
tests were made only with the tail wheel attached.

Condition of seaway.-

(a) Calm water in the tank and at the catapult

(b) Wave crests parallel to the flight path; height
approximately $1\frac{1}{2}$ feet to 2 feet, wave length approxi-
mately 30 to 40 feet

(c) Wave crests perpendicular to the flight path;
height approximately $1\frac{1}{2}$ feet to 4 feet, wave length
approximately 20 to 80 feet

Ditching-aid devices.-

(a) Regulation arresting hook for the SB2C-1

(b) Hydrofoil arresting hook, figure 9

RESULTS AND DISCUSSION

Summaries of the results of the tests are presented
in tables I to V.

The symbols used in defining the ditching behavior
of a model are as follows:

b   deep run - model travels through the water
            partially submerged exhibiting a tendency to
            dive, although the attitude of the model is
            nearly level

d_1 violent dive - a dive in which the wings are sub-
            merged and the angle between the water surface
            and the fuselage reference line is between $15°$
            and $90°$

d$_2$ slight dive - a dive in which the wings are not
           submerged completely and the angle between the
           water surface and the fuselage reference line
           is 15° or less

h   smooth run - a run in which there is no apparent
           oscillation about any axis during which the
           model settles into the water as the forward
           velocity decreases

p   porpoising - an undulating motion about the
           transverse axis in which some part of the model
           is always in contact with the water surface

s   skipping - an undulating motion about the transverse
           axis in which the model clears the water surface
           completely - in general, the motion is more
           severe than porpoising and greater damage
           would probably occur

t   sharp turn - a violent angular motion about a
           vertical axis, generally caused by one wing
           tip digging into the water

        Most of the violent dives listed in the tables were
vertical dives. Vertical dives are considered especially
hazardous because of the probability that the airplane
may overturn and trap the occupants.

        In the tank when the model dived the maximum decelera-
tion ranged from 4g to 8g. When the model did not dive
the maximum deceleration ranged from 0.9g to 2.5g
(table I). In accord with the Laws of Similitude the
decelerations would be the same for the actual airplane.
No decelerations were measured in the catapult tests.

        Photographs showing the characteristic behavior are
shown in figures 10 through 13. Figures 14 and 15 give
typical time histories of longitudinal decelerations.

                        Effect of Flaps

        In the tank tests, lowering the flaps to the full-
down position caused the model to dive consistently while
lowering the flaps to the half-down position caused an
occasional dive. (See table I and fig. 10.) In these

tests the flaps rarely failed. In the catapult tests
lowering the flaps did not generally cause the model to
dive (table II) because at least one flap always failed
and both flaps failed in 80 percent of the tests. The
more frequent flap failure in tests at the catapult may
be due to higher impact loads. Higher loads might be
caused by the rougher water surface (ripples occurred
even in calm water) or by the slightly higher vertical
velocities found in the catapult tests.

From the test results it might be expected that in
ditching the full-scale airplane at a low sinking speed
in smooth water, the flap structure might be bent in
such a way as to obtain a stress just below the yield
point of the flap structure, thereby producing a diving
moment. In rough water the probability of a dive due to
this moment is minimized because the impact loads are
severe enough to either shut or tear away the flaps
before they have had very much effect on the attitude
of the airplane.

It appears likely that the flaps can be lowered
half down without causing a dive but, with flaps full
down, the probability that diving will occur is
increased. If ditchings are made with flaps up, the
landing speeds will be so high that very severe damage
may be expected. These considerations indicate that
this airplane should be ditched with the flaps half down.

Effect of Attitude

Table I shows that, for the condition of least
damage, decelerations tended to decrease slightly with
decreasing attitude. At the worst damage condition,
however, decelerations increased substantially as the
attitude was decreased.

Since damage is generally expected to ge greater
than that simulated in the condition of least damage,
a near-stall landing should generally cause less
deceleration than a low attitude ditching.

Effect of Weight

The general behavior of the model did not vary
much with change in gross weight and the effects of

gross weight on decelerations were inconsistent. (See
tables I, III, and IV.) Since the results show that a
reduction in weight does not tend to cause any increase
in violence of behavior, ditchings made at the lightest
gross weight obtainable should be the safest because
of the accompanying decrease in landing speed; as a
result of the lower landing speed less damage may be
expected.

Effect of a Wing-Low Landing

In the course of the tests a number of landings
were inadvertently made in which the wings were not
laterally level. When the wing tip dug into the water,
the model usually made a violent turn coming to a
sudden stop as shown in figure 12(a). If the wing that
was low made contact with the water all along its
undersurface, the model usually rode the waves or made
a skidding turn.

Effect of Simulated Damage

Skipping and porpoising usually occurred in both
the tank and catapult tests when the bomb-sight doors
were removed (tables I and II). Tank tests showed that
the removal of the bomb-lever doors in addition to the
bomb-sight doors, had little effect on the performance.
Removal of the bomb-bay doors in addition to the bomb-
sight and bomb-lever doors caused the model to behave
more violently. In the tank tests, dives occurred
fairly regularly and, although dives were obtained only
occasionally in the catapult tests, a tendency to dive
was shown by deep runs.

When the model was ditched at speeds above
104.3 knots, with the bomb-bay doors, bomb-lever doors,
and bomb-sight doors removed, the water forces on the
bottom of the model were frequently large enough to tear
out about one-third of the bottom of the fuselage aft
of the bomb bay.

Effect of Tail Wheel

Tables I and III show inconsistent effects due to
the removal of the tail wheel. However, studies of the

motion pictures taken during the tests, indicate that
the motions tended to be somewhat more violent when
the tail-wheel unit was on than when it was off.

Effect of Ditching Aids

In general, the tests showed that the ditching
behavior was more violent with the regular arresting
hook extended. (Compare tables I and V.) The decelera-
tions were increased by about 0.5g to 2.0g and the length
of run shortened. When it was found that no improvement
in the ditching performance was obtained with a regular
arresting hook, tests were made with the lower portion
of the hook replaced by a hydrofoil, shown in figure 9.
The hydrofoil was made as large as could be fitted into
the arresting-hook tunnel and no attempt was made to
shape it so that it would be practicable for picking
up the arresting-gear cable for it seemed desirable to
evaluate the possible improvement that could be obtained
before entering into such a design problem. An improve-
ment in the ditching behavior at the 15° attitude, flaps
up (with simulated damage of the bomb-sight doors, bomb-
lever doors, and bomb-bay doors) was obtained with this
hydrofoil arresting hook. This change in behavior was
from violent dives to skipping or porpoising. The
length of run was also increased. The ditching behavior
for the 8° and 2° attitudes was not changed appreciably.

Effect of Seaway

The wave height obtained for a given wind velocity
at the catapult is smaller than the wave height obtained
in the open sea for the same velocity. Consequently,
in ditchings, the wave heights are lower than they
should be to correspond to the ground speeds at which the
model lands. It is possible then that the ditching
behavior obtained at the catapult, in rough water, may be
somewhat optimistic.

When ditched parallel to the wave crests, the model
generally skipped or porpoised (table II and fig. 13(a)).
When the model was ditched across the waves, skipping was
predominant although some smooth runs were obtained when

the model touched the water surface in the trough of a
wave. A dive resulted when the tail of the model hit
the leeward side of a wave near the crest.

Since diving is such a severe motion, the airplane
should generally be ditched parallel to the waves to
reduce the possibility of a dive occurring; however, if
a strong cross wind exists, it may not be feasible to
ditch parallel to the waves. (See reference 2.)

CONCLUSIONS

From results of the tests of a 1/8-size model of
the SB2C-1 airplane, the following conclusions were
drawn:

1. The airplane should be ditched in a normal tail-
down landing attitude (thrust line at 15°) with flaps
half down.

2. In rough water, ditchings should be made along
the wave crests when feasible. If a strong cross wind
exists, it may be necessary to land across the waves
and, in such a case, an attempt should be made to have
the tail of the airplane touch the windward side of a
wave.

3. If the bomb-bay doors do not fail, skipping will
probably occur but if the bomb-bay doors do fail, an
event which probably will occur in the full-scale airplane,
a dive may result.

4. If one wing tip digs into the water, a violent
turn may result.

5. The arresting-gear hook should not be extended
in ditching.

6. A slight improvement in the ditching behavior is obtained when the tail wheel is retracted.

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REFERENCES

1. Fisher, Lloyd J., and Steiner, Margaret F.: Ditching Tests with a 1/12-Size Model of the Army B-26 Airplane in NACA Tank No. 2 and on an Outdoor Catapult. NACA MR, Aug. 15, 1944.

2. Anon.: Landplane Ditching Manual Prepared. Air Sea Rescue Bull. No. 4, Air Sea Rescue Agency (Washington), Oct. 1944, pp. 4-8.

TABLE I.- SUMMARY OF THE RESULTS OF TANK DITCHING TESTS OF A 1/8-SIZE MODEL

OF THE SB2C-1 AIRPLANE WITH THE TAIL-WHEEL UNIT ATTACHED

[All values are full scale; gross weight, 13,060 pounds]

Note: In each cell two values are stacked (shown here as "upper / lower"). Column groups by attitude of thrust line: the first four speed groups are attitude 15°; the next five are attitude 8°; the last three are attitude 2°.

Damage condition	Flaps	15°/60.8(70) Max	Run	Rem	15°/69.5(80) Max	Run	Rem	15°/78.2(90) Max	Run	Rem	15°/86.8(100) Max	Run	Rem	8°/78.2(90) Max	Run	Rem	8°/86.8(100) Max	Run	Rem	8°/95.6(110) Max	Run	Rem	8°/104.3(120) Max	Run	Rem	8°/112.9(130) Max	Run	Rem	2°/95.6(110) Max	Run	Rem	2°/104.3(120) Max	Run	Rem	2°/112.9(130) Max	Run	Rem
Bomb-sight door removed	Full up							1.3 / 1.2	13 / 15	s / s	1.2 / .9	19 / 19	s / s										1.4 / 1.8	18 / 19	p / p	1.3 / 2.0	22 / 21	jf / jf									
	Half down				5.0 / 5.3	3 / 3	d_1 / d_1	6.0 / 5.4	3 / 4	d_1 / d_1				1.4 / 1.1	15 / 13	s / s	1.8	10	p	2.0 / 2.3	15 / 14	h / h													2.0 / 1.7	14 / 15	s / s
	Full down	4.8 / 4.8	2 / 2	d_1 / d_1	5.8 / 5.9	2 / 2	d_1 / d_1							6.5 / 7.0	4 / 2	d_1 / d_1	7.4 / 7.0	5 / 3	d_1 / d_1										2.9 / 1.6	9 / 13	s / s	6.0 / 5.8	3 / 3	d_1 / d_1			
Bomb-sight door and bomb-lever doors removed	Full up							1.3 / 1.6	18 / 19	s / s	1.5 / 2.0	24 / 20	s / s										1.8 / 3.8	22 / 21	p / p	1.8 / 1.8	24 / 26	s / s									
	Half down				1.4 / 1.6	5 / 6	d_1 / d_1	1.6 / 2.8	8 / 7	d_1 / d_1				2.0 / 1.9	5 / 5	s / s	5.8 / 2.4	4 / 6	d_1 / d_1	2.5 / 2.3	14 / 13	s / s													2.0 / 1.7	16 / 17	s / s
	Full down	4.6 / 4.3	5 / 2	d_1 / d_1	4.1 / 6.0	4 / 5	d_1 / d_1							6.0 / 5.8	6 / 6	d_1 / d_1	7.0 / 7.5	2 / 3	d_1 / d_1										7.1 / 5.3	4 / 4	d_1 / d_1	6.5 / 6.0	5 / 7	d_1 / d_1			
Bomb-sight door and bomb-lever doors and bomb-bay doors removed	Full up							4.0 / 3.8	6 / 5	d_1 / d_1	4.5 / 4.5	6 / 6	d_1 / d_1										5.2 / 4.6	8 / 7	d_1 / d_1	6.5 / 7.0	11 / 12	s / s									
	Half down				5.1 / 5.1	3 / 3	d_1 / d_1	4.8 / 5.0	4 / 4	d_1 / d_1				5.0 / 5.0	3 / 2	d_1 / d_1	5.0 / 5.3	3 / 2	d_1 / d_1	4.8 / 5.0	7 / 4	d_1 / d_1													7.8 / 7.8	3 / 4	d_1 / d_1
	Full down	3.6 / 3.8	2 / 2	d_1 / d_1	3.2 / 5.0	5 / 5	d_1 / d_1							6.2 / 6.0	5 / 5	d_1 / d_1	7.1 / 7.4	4 / 5	d_1 / d_1										7.8 / 7.7	2 / 2	d_1 / d_1	7.7 / 7.7	3 / 2	d_1 / d_1			

(1) Column headings are explained as follows:

Max. - Maximum deceleration, given in multiples of the acceleration of gravity

Run - Length of run, given in multiples of the length of the airplane

Remarks - Notations under this heading have the following meaning:

d_1 - dived, violently

h - ran smoothly

p - porpoised

s - skipped

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TABLE II.- SUMMARY OF RESULTS OF CATAPULT DITCHING TESTS OF A 1/8-SIZE MODEL OF THE SB2C-1 AIRPLANE

[All values are full scale; gross weight, 13,060 pounds]

Damage condition	Attitude of thrust line (deg)	Flaps	Airspeed (knots)	Calm		Along the waves crests			Across the waves crests		
				Wind range (knots)	[1]Remarks	Wind range (knots)	Wave height (in.)	[1]Remarks	Wind range (knots)	Wave height (in.)	[1]Remarks
Bomb-sight door removed	15	Full up	84.3	0 – 14	s	5 – 19	16 – 24	s,p,h	3 – 36	16 – 48	s,h, [2]d_1
	15	Full down	70.4		s,p,b		16 – 24	s,h,t		16 – 48	s,h
	8	Full up	112.9		p,h		8 – 16	s		8 – 16	s,p
	8	Full down	83.5		s, [3]d_1		16 – 24	s		8 – 16	s,p
	2	Full down	104.5		t,s		16 – 24	s		8 – 16	s
Bomb-sight doors, bomb-lever doors, bomb lever doors removed	15	Full up	84.3	0 – 11	b	2 – 17	16	p,b	4 – 40	16 – 24	h, [2]d_1
	15	Full down	70.4		b,s		16 – 24	p		16 – 48	h, d_2
	8	Full up	112.9		p		16 – 24	s,d_2		16	s
	8	Full down	83.5		s, [3]d_1		8	s,t		8 – 24	s,b
	2	Full down	104.5		t,s		16 – 24	s,t		8 – 24	s,h,t

[1]Notations used are identified as follows:

    b - ran deeply
    d_1 - dived, violently
    d_2 - dived, slightly
    h - ran smoothly
    p - porpoised
    s - skipped
    t - turned sharply

[2]Dive caused by the tail of the model hitting the leeward side of a wave near the crest.

[3]One flap failed.

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TABLE III.- SUMMARY OF THE RESULTS OF TANK DITCHING TESTS OF A 1/8-SIZE MODEL OF THE SB2C-1 AIRPLANE WITHOUT THE TAIL-WHEEL UNIT ATTACHED

[All values are full scale; gross weight; 13,060 pounds]

Damage condition	Flaps (1)	15 60.8 kt / 70 mph Max.	Run	Rem.	69.5 / 80 Max.	Run	Rem.	78.2 / 90 Max.	Run	Rem.	86.8 / 100 Max.	Run	Rem.	8 78.2 / 90 Max.	Run	Rem.	86.8 / 100 Max.	Run	Rem.	95.6 / 110 Max.	Run	Rem.	104.3 / 120 Max.	Run	Rem.	112.9 / 130 Max.	Run	Rem.	2 95.6 / 110 Max.	Run	Rem.	104.3 / 120 Max.	Run	Rem.	112.9 / 130 Max.	Run	Rem.
Bomb-sight door removed	Full up							1.2/1.4	17/18	h/h	2.0/1.9	13/14	p/p										3.8/2.4	19/21	p/p	2.3/2.9	34/26	p/p									
	Half down					3/3	d1/d1		4/3	d1/d1					4/4	d1/d1		2/3	d1/d1	8.0/8.0	1/1	d1/d1														5/5	d1/d1
	Full down					1/2	d1/d1		2/2	d1/d1				8.0/7.7	4/4	d1/d1	8.0/7.9	4/4	d1/d1											2/2	d1/d1		1/2	d1/d1			
Bomb-sight door and bomb-lever doors removed	Full up							0.7/1.0	18/15	p/p	5.9/5.1	18/14	p/p										4.2/4.1	19/19	h/h	3.0/2.8	26/25	s/s									
	Half down				6.0/5.4	2/1	d1/d1	4.1/5.0	2/3	d1/d1				7.3	1/1	d1/d1	8.0/8.0	1/1	d1/d1	8.0/8.0	1/1	d1/d1														3/4	d1/d1
	Full down	6.1/6.0	2/3	d1/d1		3/3	d1/d1							6.8/6.4	3/2	d1/d1	6.4/8.2	4/4	d1/d1											4/4	d1/d1		4/3	d1/d1			
Bomb-sight door, bomb-lever doors and bomb-bay doors removed	Full up							3.4/3.9	9/10	s/s	3.9/4.0	12/9	s/s										7.3/7.0	3/4	d1/d1	7.0/7.0	2/4	d1/d1									
	Half down					2/3	d1/d1		3/5	d1/d1				4.3	3/3	d1/d1	4.2	5/3	d1/d1	3.2	5/3	d1/d1													7.0	5/5	d1/d1
	Full down	1.9/2.6	3/2	d1/d1	4.8/2.9	2/3	d1/d1								5/4	d1/d1		4/4	d1/d1											3/5	d1/d1		5/5	d1/d1			

(1) Column headings are explained as follows:
Max. - Maximum deceleration, given in multiples of the acceleration of gravity.
Run - Length of run, given in multiples of the length of the airplane.
Remarks - Notations under this heading have the following meaning:
  d_1 - dived, violently
  h - ran smoothly
  p - porpoised
  s - skipped

TABLE IV.--SUMMARY OF THE RESULTS OF DITCHING TESTS OF A 1/8-SIZE MODEL OF THE SB2C-1 AIRPLANE

AT TWO GROSS WEIGHTS, 11,090 POUNDS AND 15,704 POUNDS

[All values are full scale]

Gross weight (lb)	Damage condition (2)	Flaps (1)	Attitude of thrust line (deg) 15												Attitude 2												
			69.5 knots / 80 mph			78.2 knots / 90 mph			86.8 knots / 100 mph			95.6 knots / 110 mph			86.8 knots / 100 mph			95.6 knots / 110 mph			104.3 knots / 120 mph			112.9 knots / 130 mph		
			Max.	Run	Remarks	Max.	Run	Remarks	Max.	Run	Remarks	Max.	Run	Remarks	Max.	Run	Remarks	Max.	Run	Remarks	Max.	Run	Remarks	Max.	Run	Remarks
11,090	1-R	Full up	7 / 7		p / p	5.8 / 5.8	7 / 6	p / p																		
	1-E	Full up	7 / 7		p / p		6 / 7	p / p																		
	2-R	Full down													8.0 / 8.0	1 / 1	d_1 / d_1		1 / 1	d_1 / d_1						
	2-E	Full down														2 / 2	d_1 / d_1		3 / 3	d_1 / d_1						
15,704	1-R	Full up							7.0 / 7.0	8 / 7	s / s	1.8	21 / 12	s / s												
	2-E	Full down																			3.7 / 2.3	4 / 8	d_2 / d_2	2.8 / 3.0	9 / 8	d_2 / d_2

(1) Column headings are explained as follows:
Max. - Maximum deceleration, given in multiples of acceleration of gravity.
Run - Length of run, given in multiples of the length of the airplane.
Remarks - Notations under this heading have the following meaning:
d_1 - dived, violently
d_2 - dived, slightly
p - porpoised
s - skipped

(2) Damage:
1-R - bomb-sight door removed, tail wheel retracted
1-E - bomb-sight door removed, tail wheel extended
2-R - bomb-sight door, bomb-lever door, bomb-bay doors removed, tail wheel retracted
2-E - bomb-sight door, bomb-lever door, bomb-bay doors removed, tail wheel extended

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TABLE V.- SUMMARY OF THE RESULTS OF TANK TESTS OF A 1/8-SIZE MODEL OF THE SB2C-1 AIRPLANE

(TAIL-WHEEL UNIT ATTACHED) WITH THE REGULAR AND A MODIFIED ARRESTING HOOK

[All values are full scale; gross weight, 13,060 pounds]

Attitude of thrust line (deg)		15											8												2			
Speed — knots		60.8			69.5			78.2			86.8			78.2			86.8			104.3			112.9			95.6		104.3
Speed — mph		70			80			90			100			90			100			120			130			100		120
Damage condition	Flaps (1)	Max.	Run	Remarks	Max.	Run	Remarks	Max.	Run	Remarks	Max.	Run	Remarks	Max.	Run	Remarks	Max.	Run	Remarks	Max.	Run	Remarks	Max.	Run	Remarks	Run	Remarks	Run	Remarks
Bomb-bay doors, bomb-lever doors, bomb-sight doors removed	**Regular arresting hook**																												
	Full up							4.0 / 4.8	1 / 2	d_1 / $\overline{d_1}$	7.2 / 7.4	3 / 3	d_1 / $\overline{d_1}$							8* / 8*	2 / 2	d_1 / $\overline{d_1}$	8* / 8*	2 / 2	d_1 / $\overline{d_1}$				
	Full down	3.8 / 4.1	2 / 3	d_1 / $\overline{d_1}$	3.7	3 / 1	d_1 / $\overline{d_1}$							4.9 / 6.3	2 / 2	d_1 / $\overline{d_1}$	5.3 / 7.6	2 / 2	d_1 / $\overline{d_1}$										
	Hydrofoil arresting hook																												
	Full up							4 / 5		s / s	8 / 8		s / s							2 / 2		d_1 / $\overline{d_1}$	3 / 2		d_1 / $\overline{d_1}$				
	Full down		3 / 2	d_1 / $\overline{d_1}$		2 / 2	d_1 / $\overline{d_1}$								4 / 5	d_1 / $\overline{d_1}$		3 / 3	d_1 / $\overline{d_1}$							1 / 3	d_1 / $\overline{d_1}$	3 / 3	d_1 / $\overline{d_1}$

(1) Column headings are explained as follows:

Max. - Maximum deceleration, given in multiples of the acceleration of gravity.

Run - Length of run, given in multiples of the length of the airplane.

Remarks - Notations under this heading have the following meaning:

  d_1 - dived, violently

  p - porpoised

  s - skipped

NACA
LMAL 36891
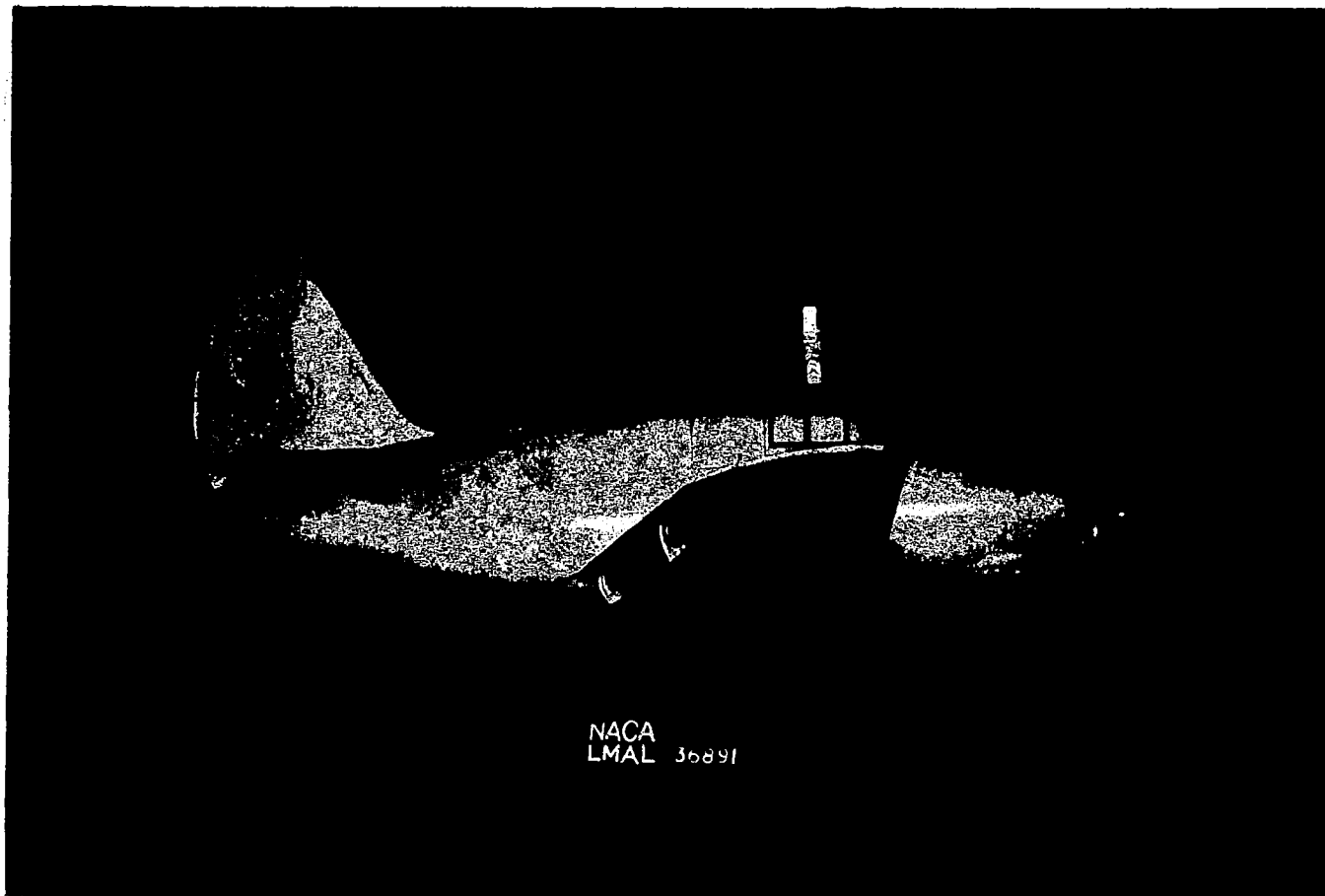
(a) Side view.

Figure 1.- Photograph showing a 1/8-size ditching
model of the Navy SB2C-1 airplane.

(b) Front view.

Figure 1.- Concluded.

Figure 2.- Arrangement for tests with scale-strength flaps.

NACA
LMAL 44298
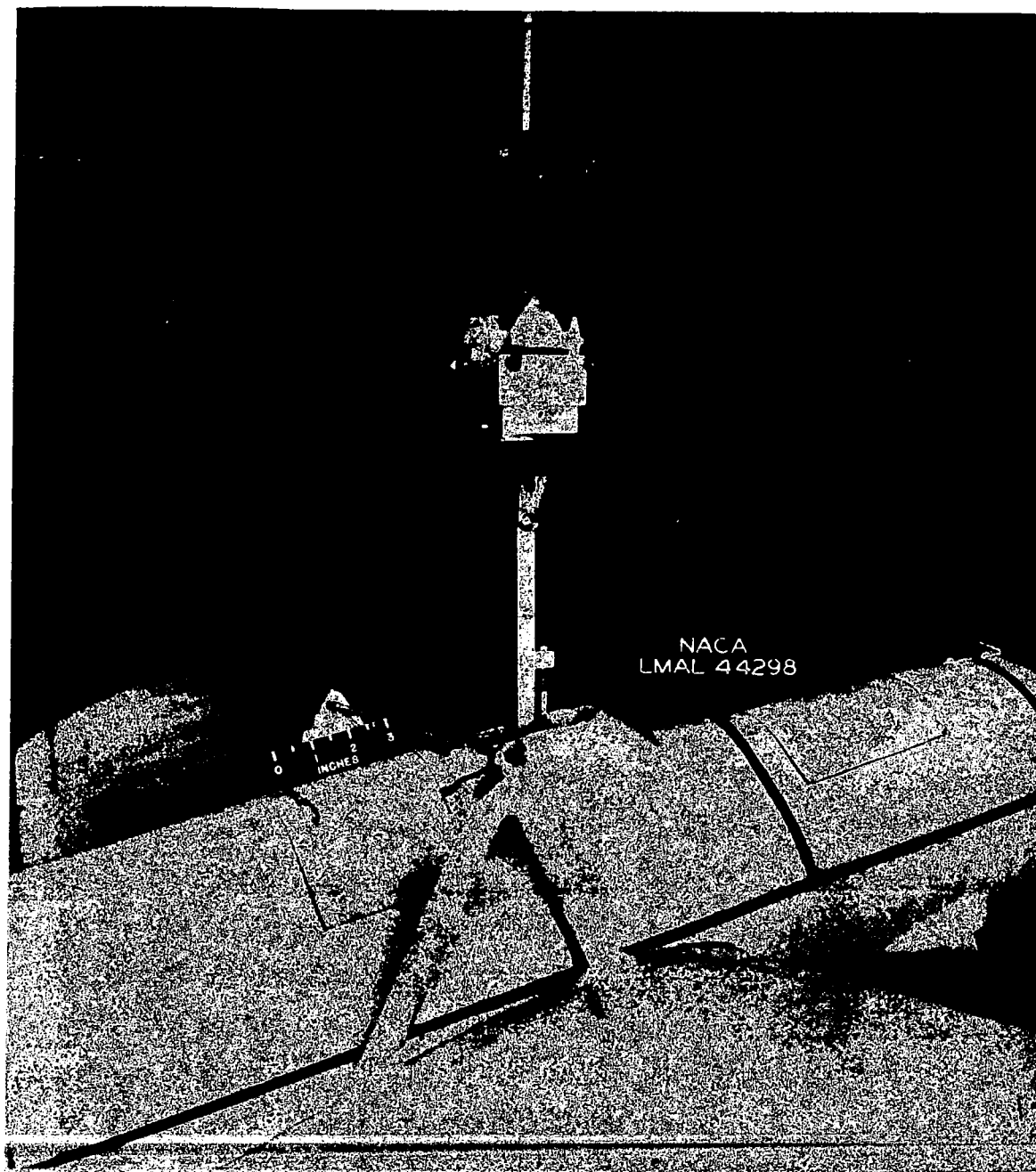
Figure 3.- Photograph of a ditching model attached to the
aerodynamic gear that replaces the launching gear at
the rear of the towing carriage.
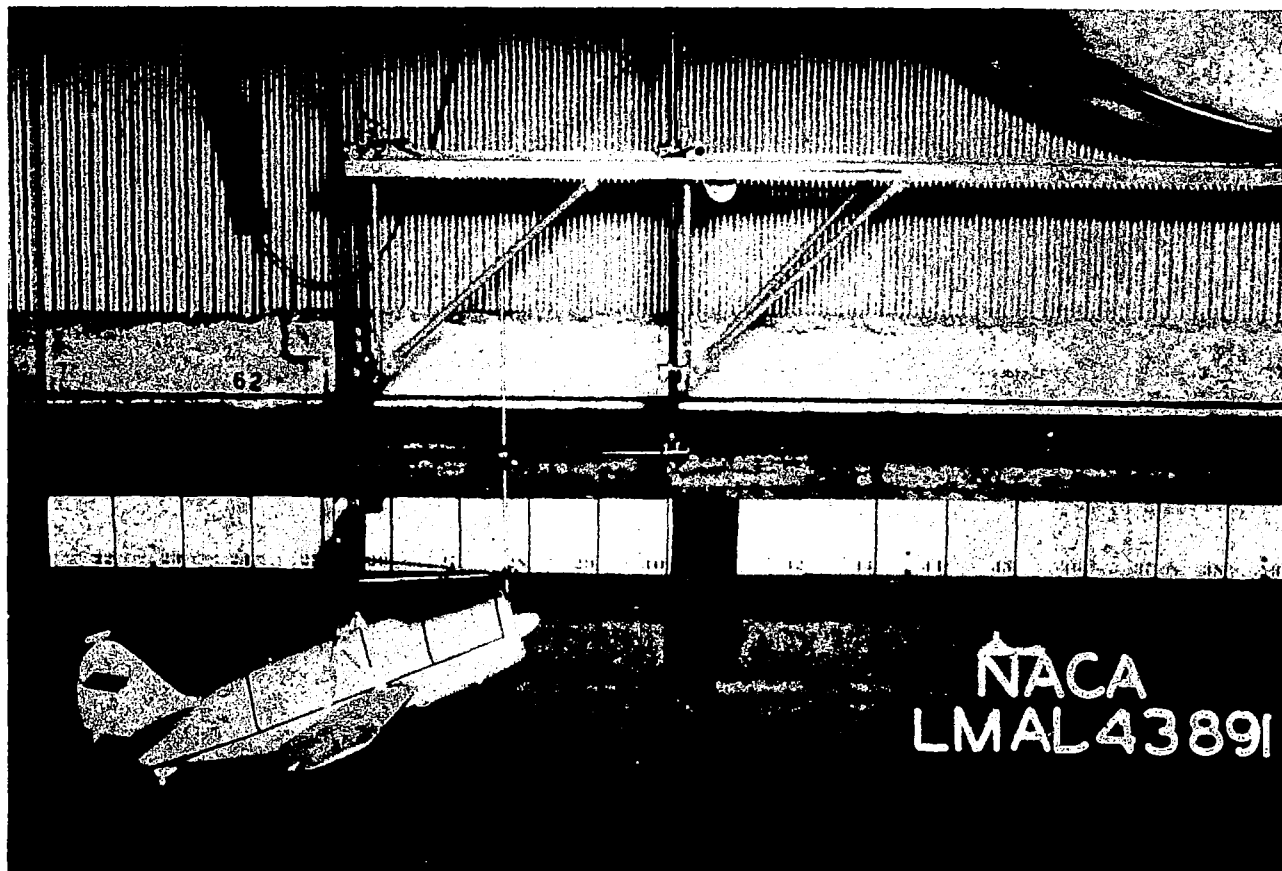
Figure 4.- Photograph of a ditching model attached
to the launching gear at the rear of the towing
carriage.

Aluminum clips

15 percent chord

5   15 $\frac{1}{2}$

$\frac{7}{8}$
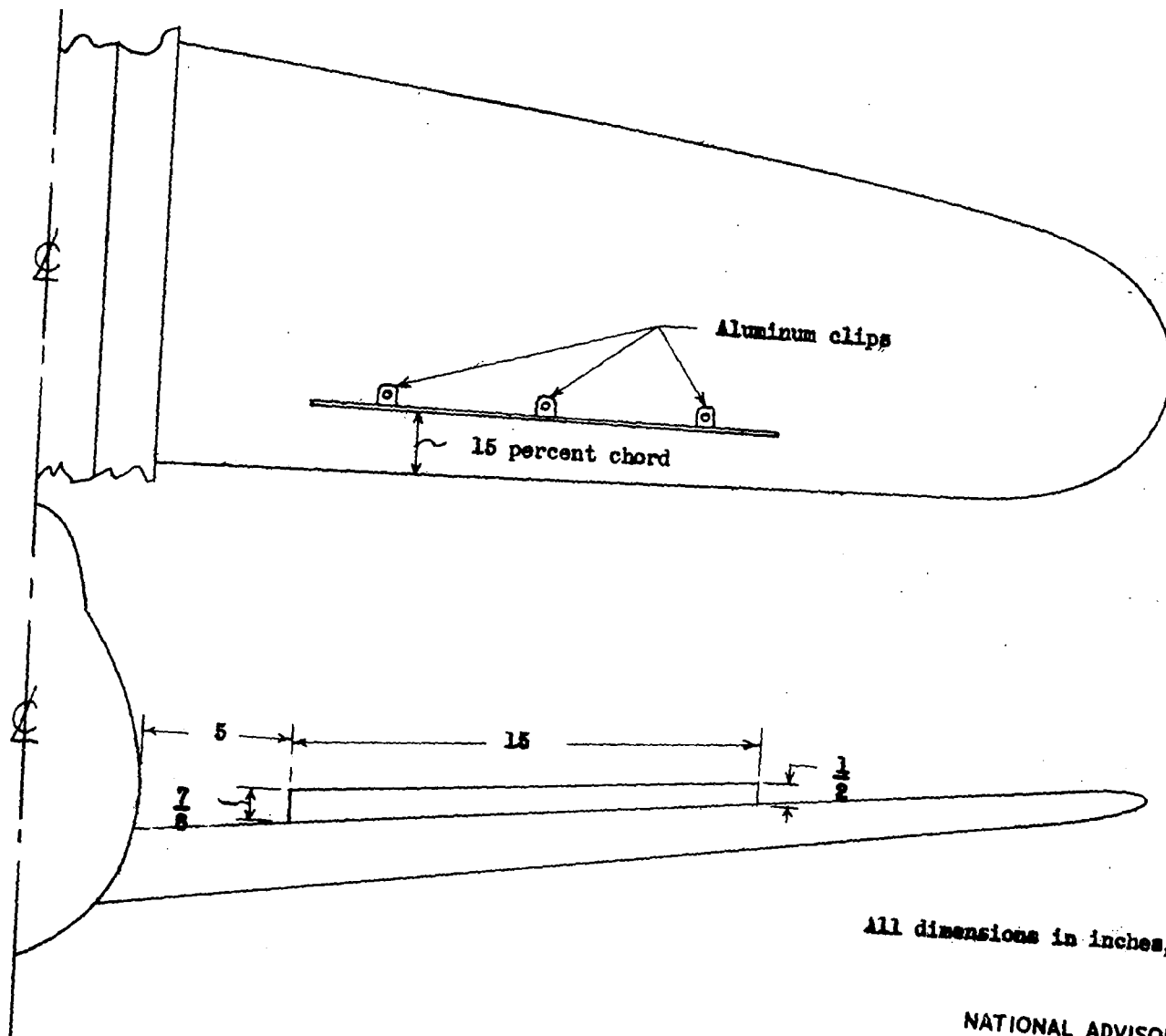
All dimensions in inches, model scale

Figure 5.- Wing spoilers.

Wire stiffener

Auxiliary elevator
of $\frac{1}{16}$ aluminum sheet

$4\frac{1}{2}$

5

Quadrant

Elevator pivot

$11\frac{1}{4}$

Thrust line

Sta. 287

All dimensions in inches, model scale.
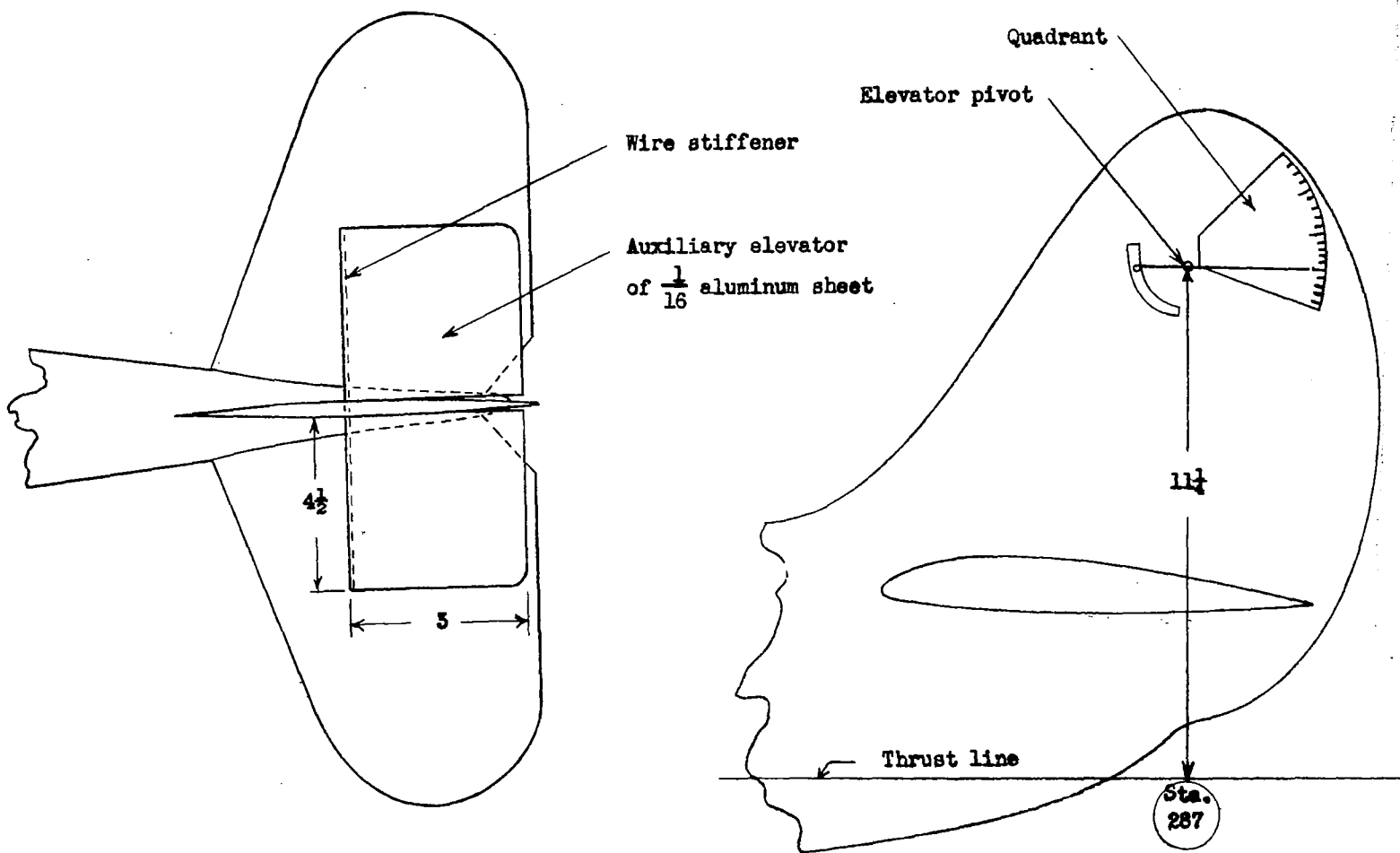
Figure 6.- Auxiliary elevator.
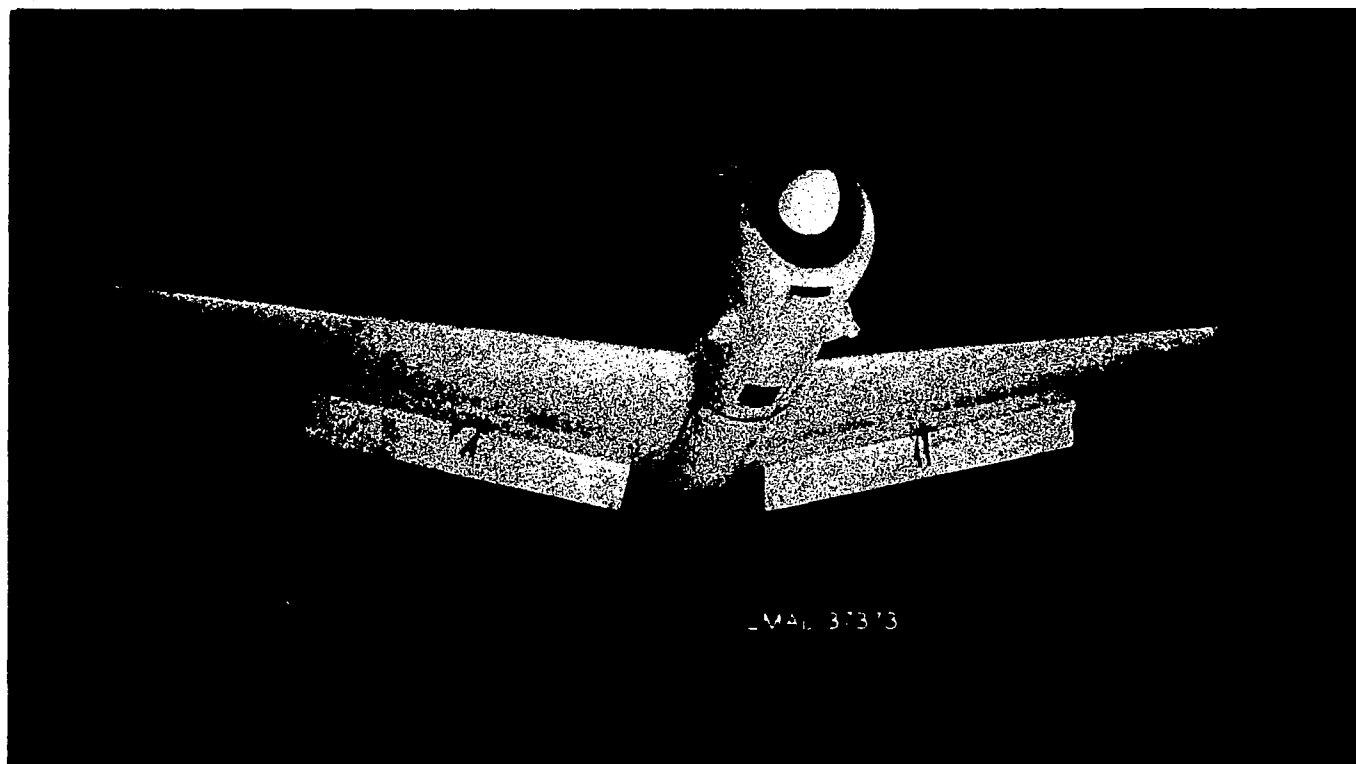
(a) Simulated damage of the bomb-sight doors.

Figure 7.- Photograph of the model showing the damage conditions used in the tests.
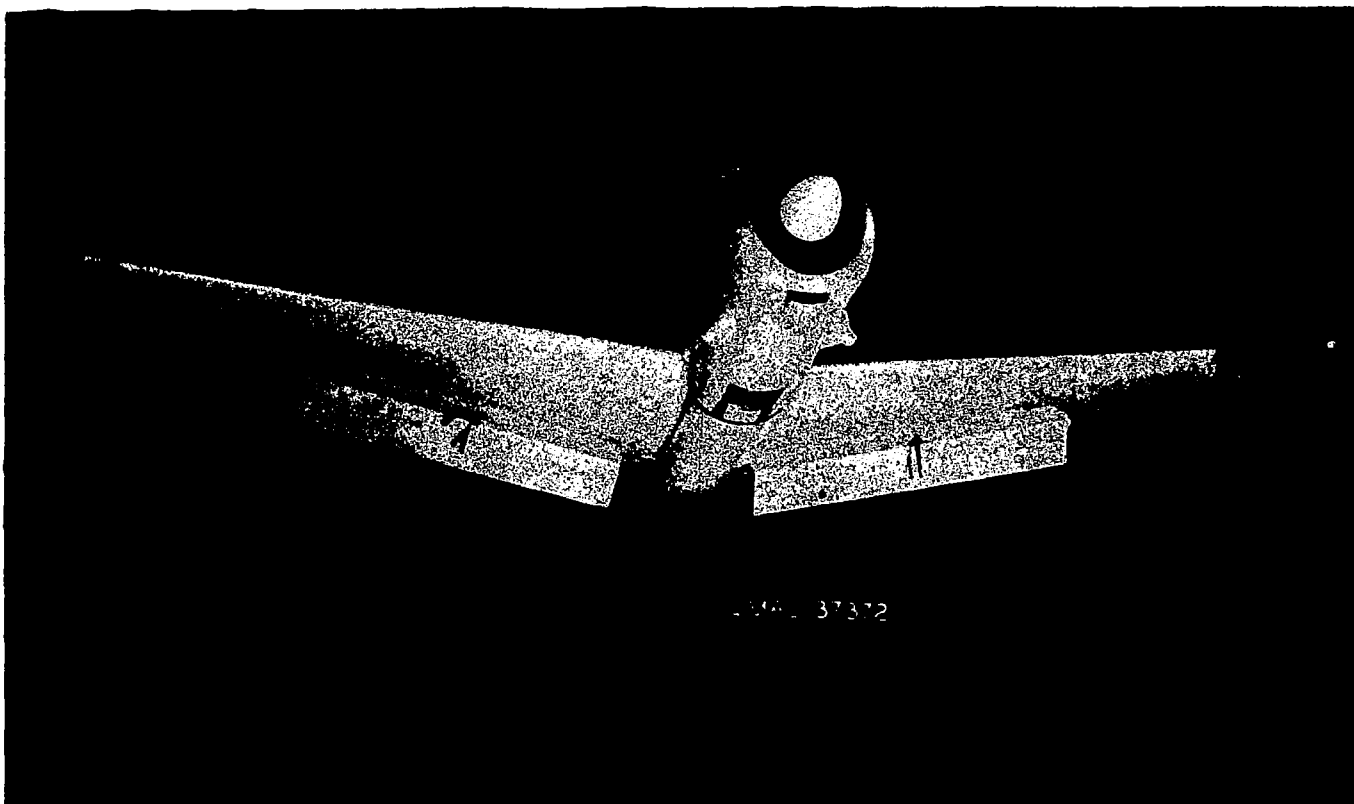
(b) Simulated damage of the bomb-sight doors
and bomb-lever doors.

Figure 7.- Continued.

LMAL 37374
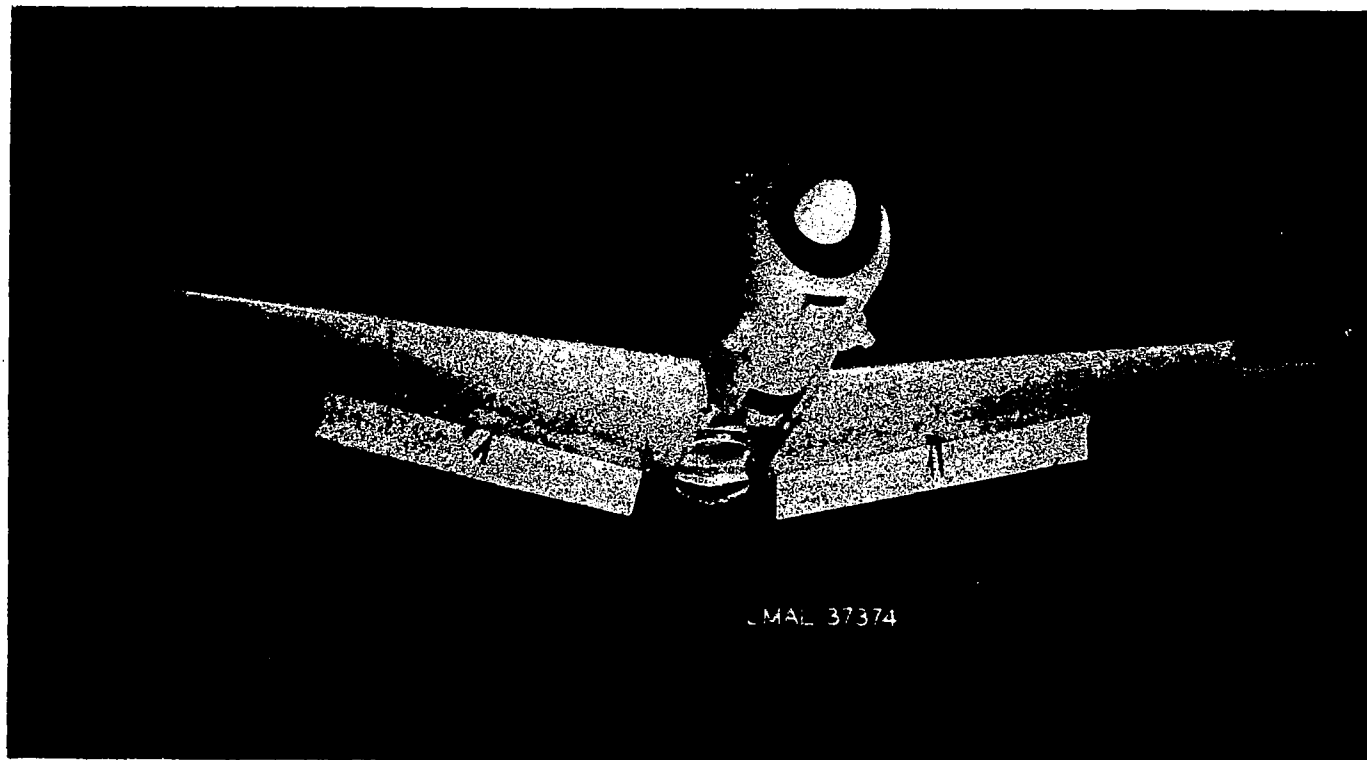
(c) Simulated damage of the bomb-sight doors,
bomb-lever doors, and bomb-bay doors.

Figure 7.- Concluded.

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274

$5\frac{1}{4}$

$1\frac{1}{4}$

1

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All dimensions in inches, model scale
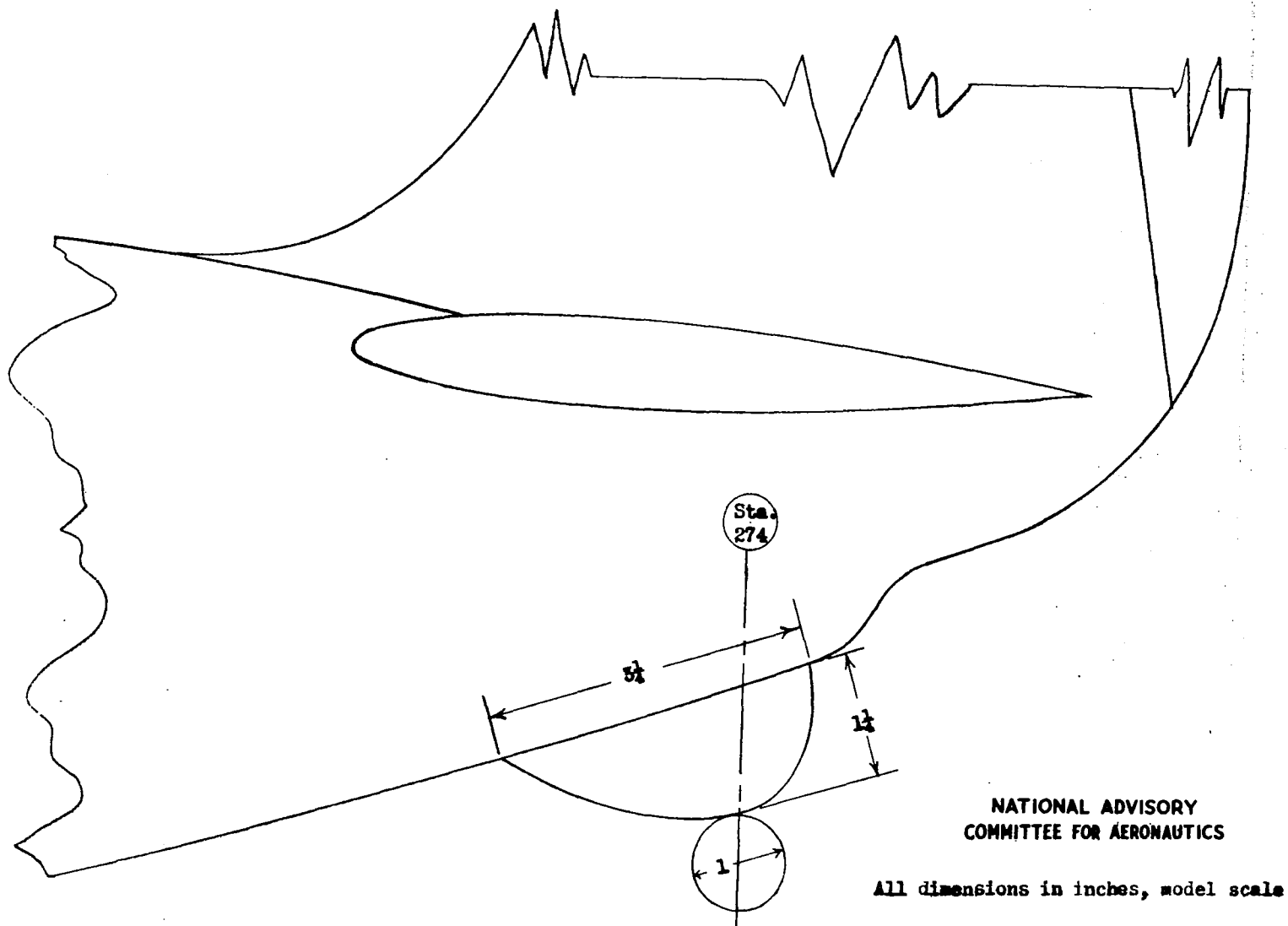
Figure 8.- Tail-wheel installation.
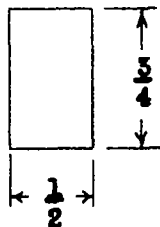
Hydrofoil plan form
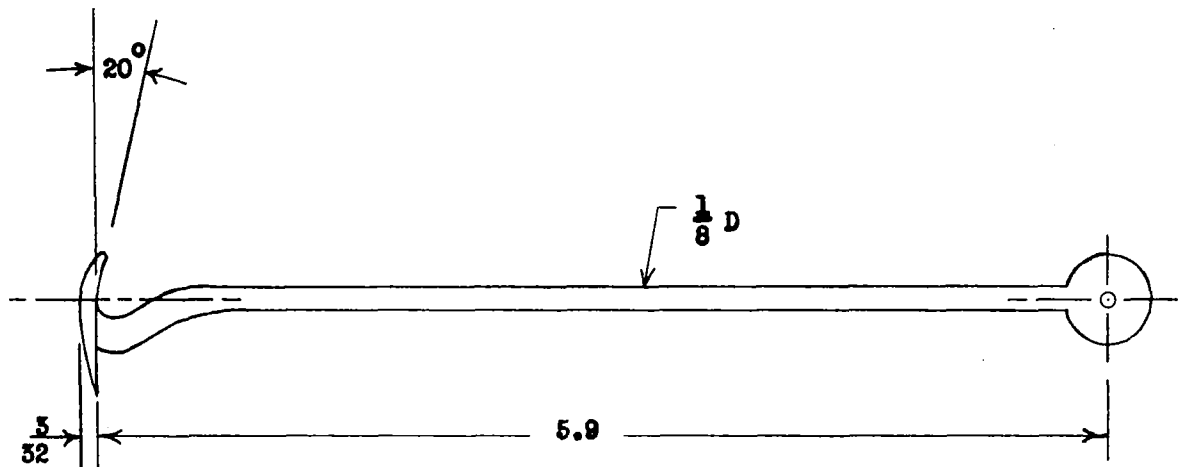
All dimensions in inches, model scale

Figure 9.- Modified arresting hook with hydrofoil.
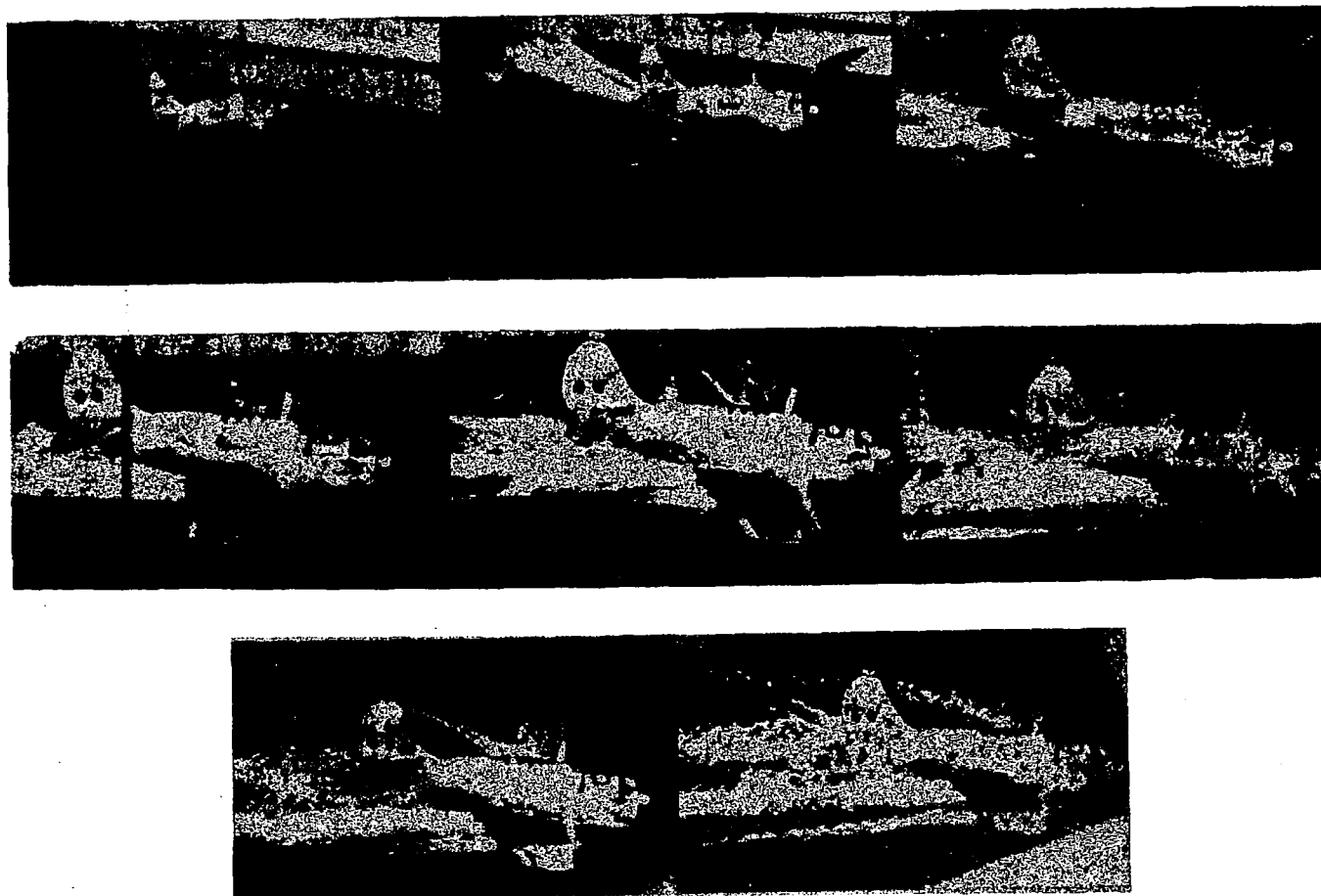
(a) Flaps full up.

Figure 10.- Photographs at 0.53-second intervals, full-scale, of ditchings of a 1/8-size
model of the SB2C-1 airplane. Attitude of thrust line, 15° at contact; bomb-sight
doors removed; speed 78.2 knots, full-scale.
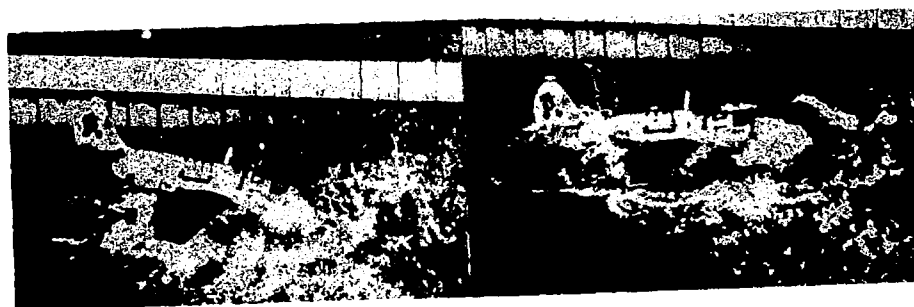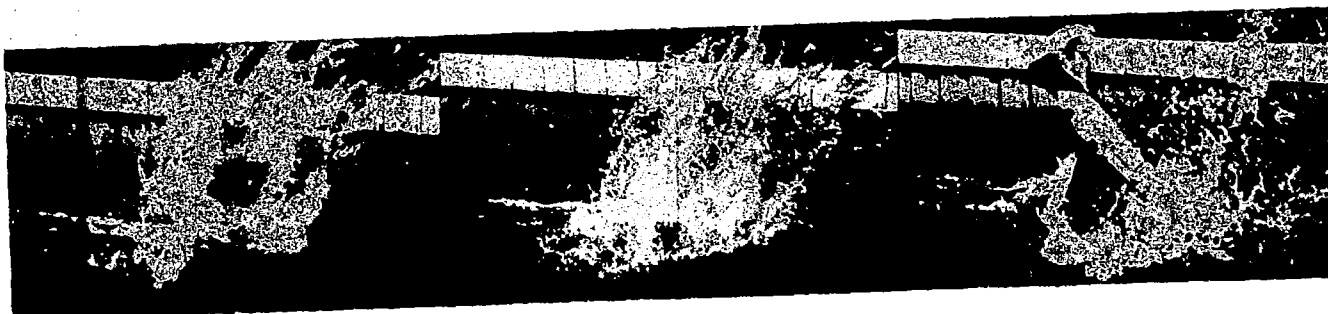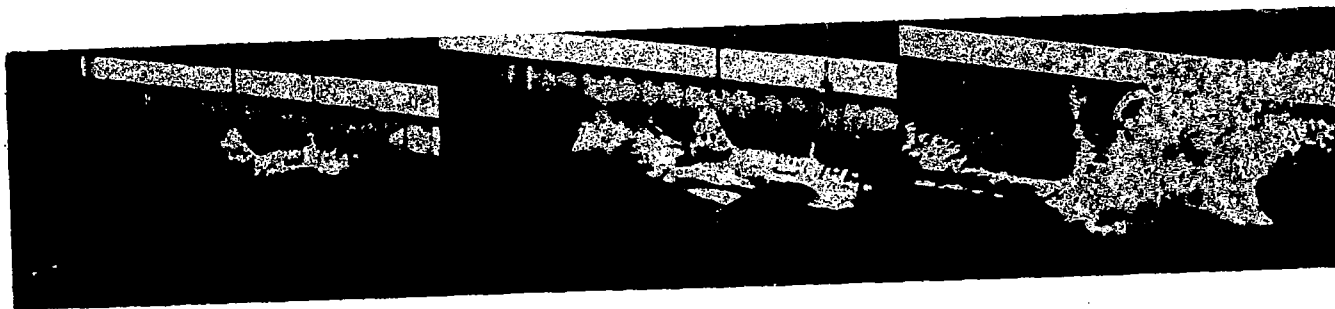
(b) Flaps full down at scale strength.

Figure 10.- Concluded.
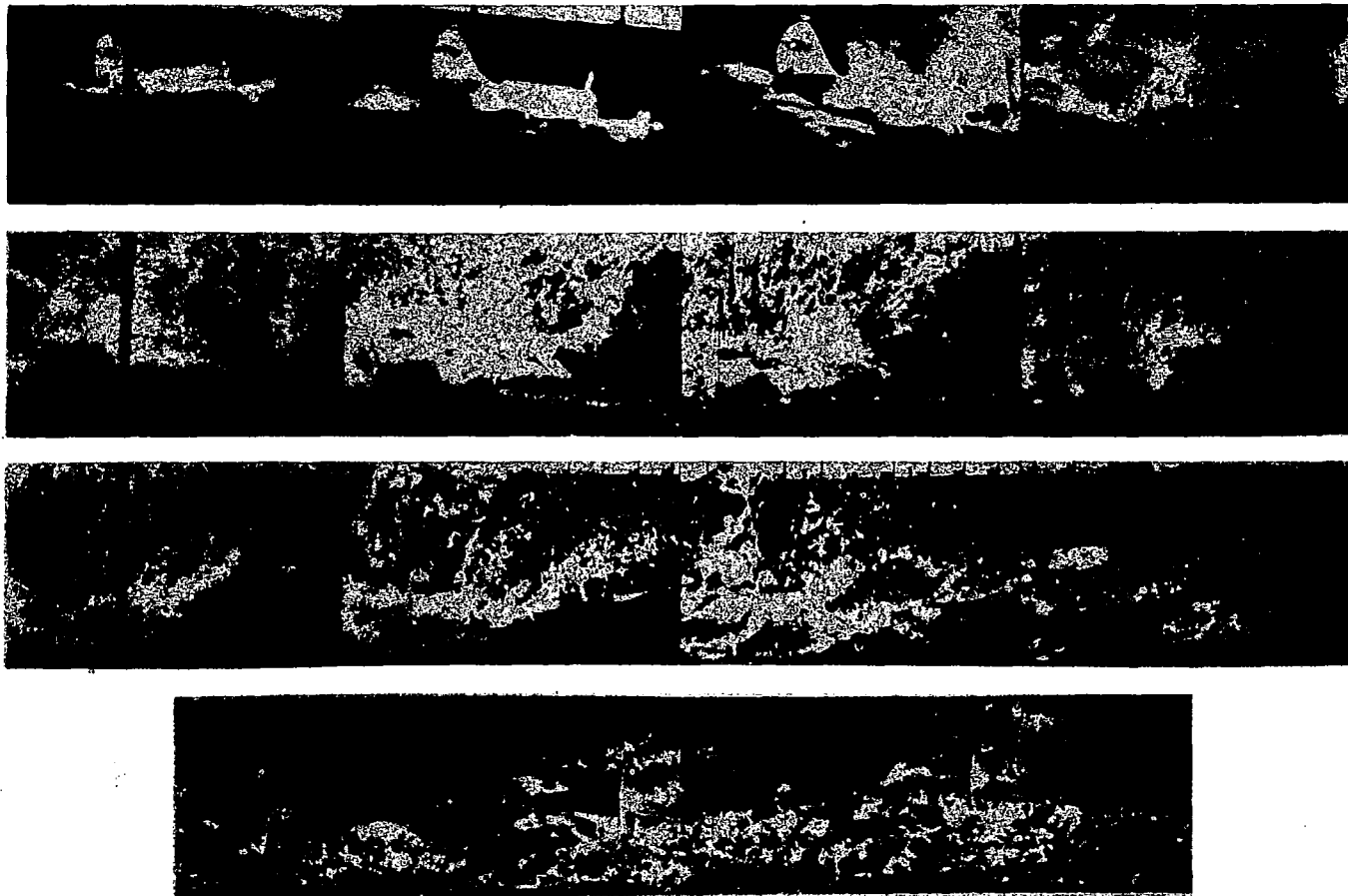
(a) Flaps full up; time interval between photographs, 0.354 second, full-scale.

Figure 11.- Photographs of ditchings of a 1/8-size model of the SB2C-1 airplane. Attitude of thrust line, 15° at contact; bomb-sight doors; bomb-lever doors; and bomb-bay doors removed; speed 78.2 knots, full-scale.

(b) Flaps full down at scale strength; time interval between photographs, 1.061 seconds, full-scale.

Figure 11.- Concluded.
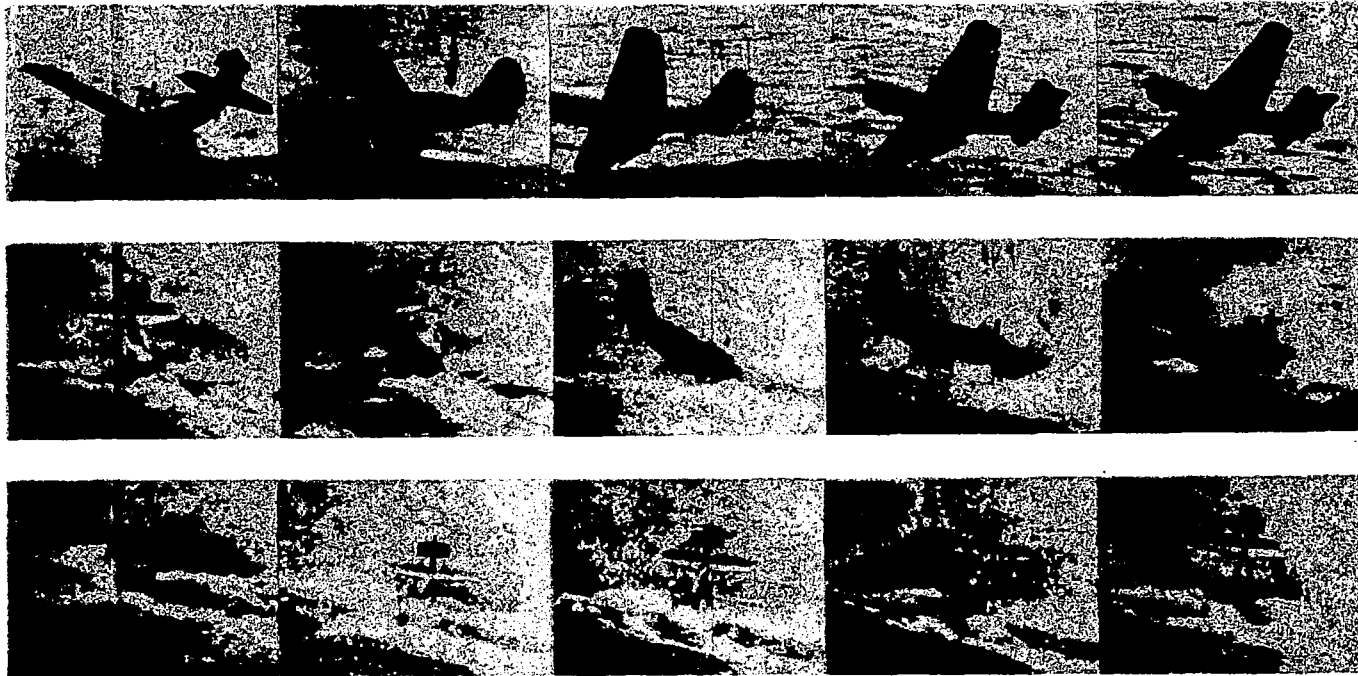
(a) Wing-low landings across the waves; wave height approximately 2 feet, full-scale; time interval between photographs, 0.212 second, full-scale.
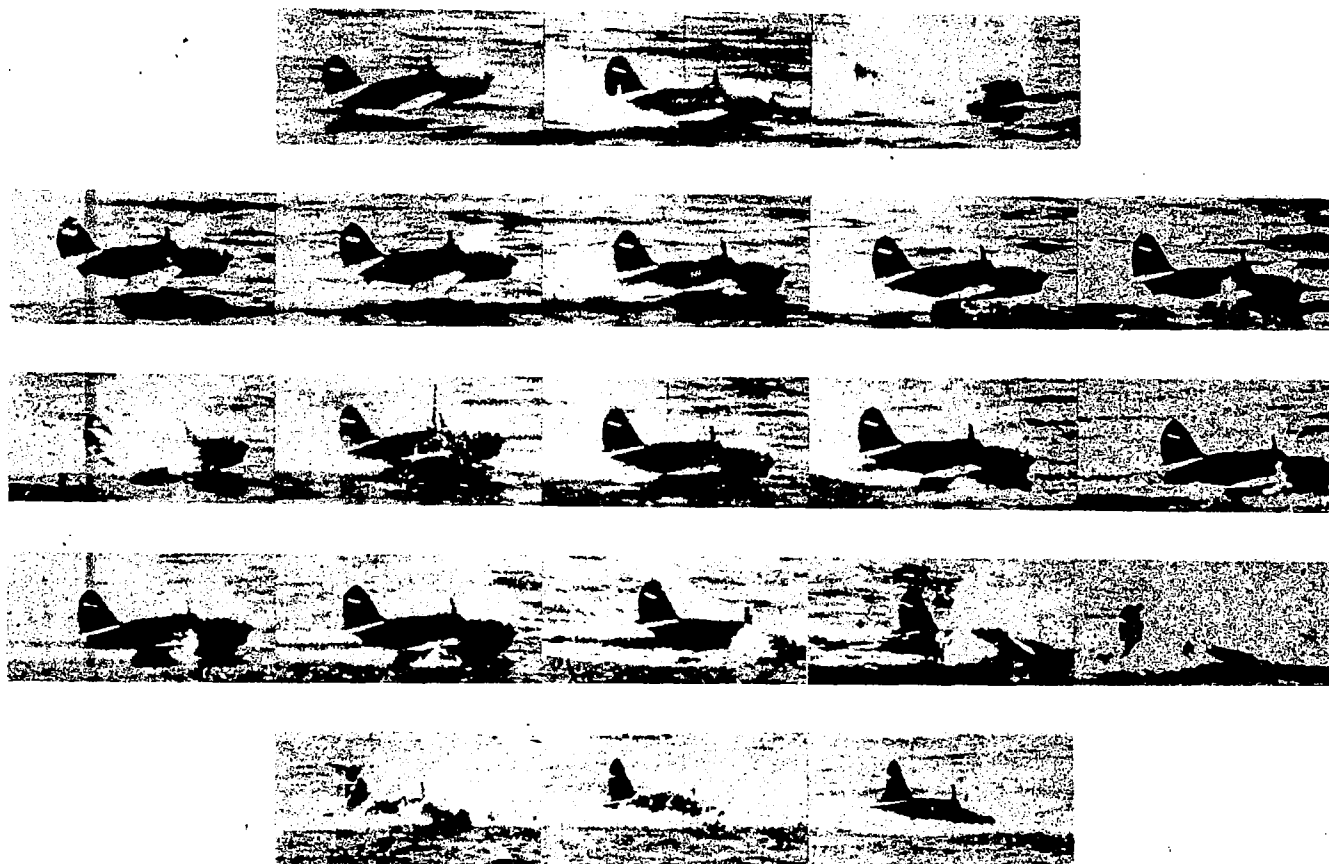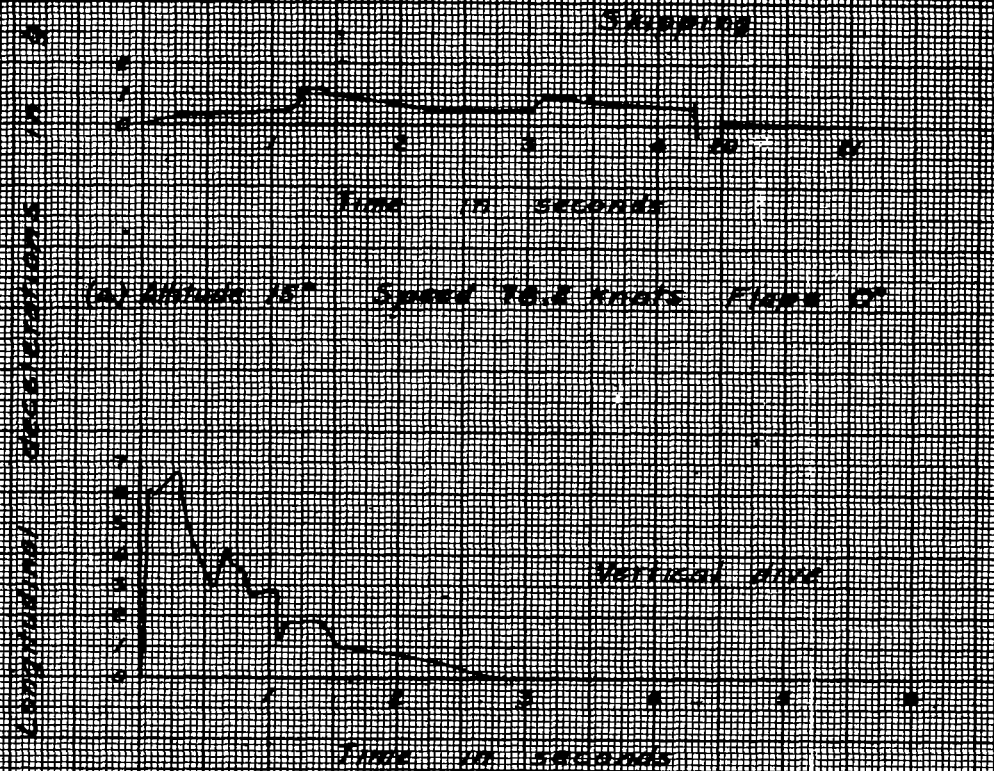
Figure 12.- Photographs of ditchings of a 1/8-size model of the SB2C-1 airplane. Attitude of thrust line, 15° at contact; flaps full down scale strength; bomb-bay doors, bomb-lever doors, and bomb-sight doors removed; speed 70.4 knots, full-scale.
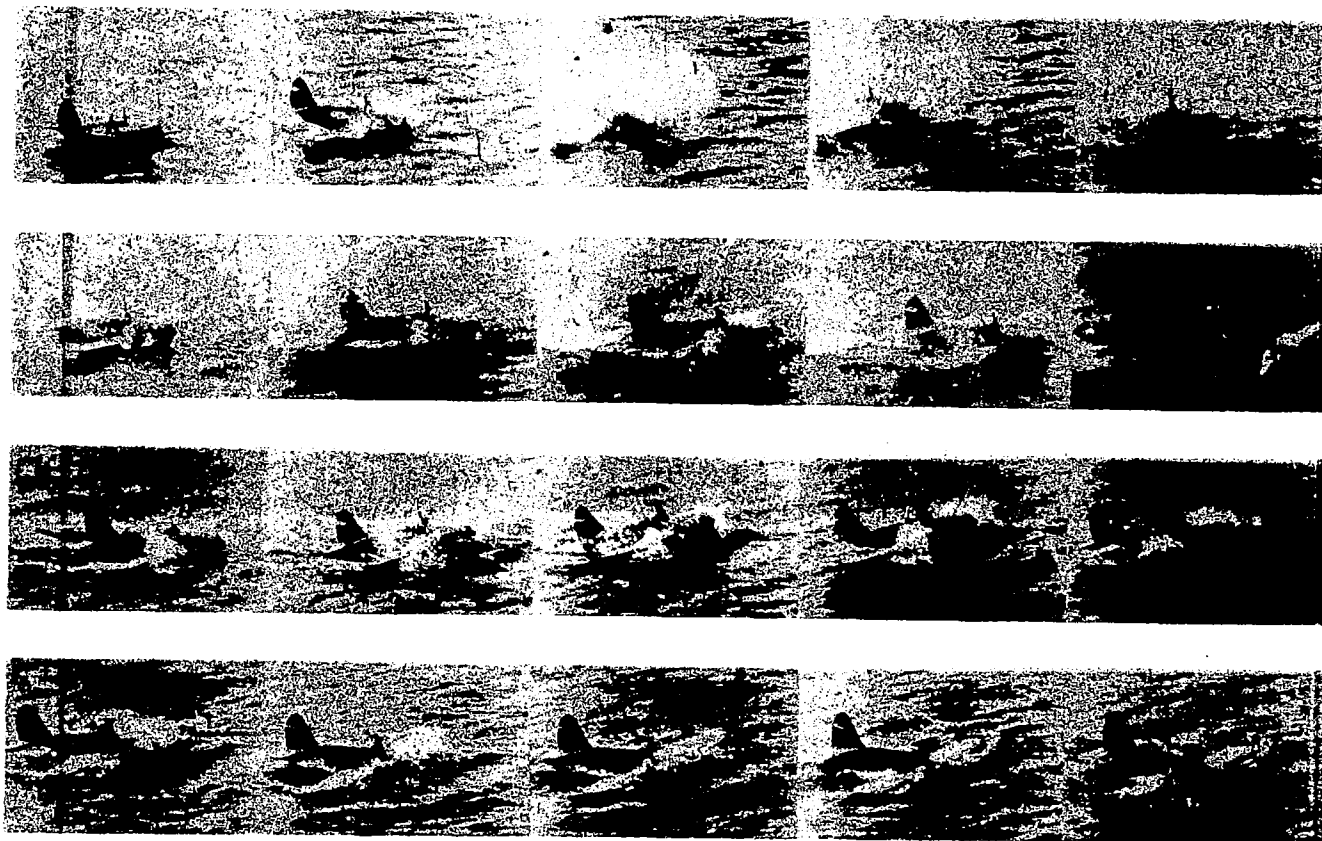
(b) Landing across the wave crests; wave height approximately 4 feet, full-scale; time interval between photographs, 0.189 second, full-scale.

Figure 12.- Concluded.

Figure 13.- Photographs at 0.212-second intervals, full-scale, of a ditching of a 1/8-size model of the SB2C-1 landing along the wave crests. Attitude of thrust line, 15° at contact; flaps full up; bomb-sight door removed; speed 84.3 knots, full-scale; wave height approximately 2 feet, full-scale.
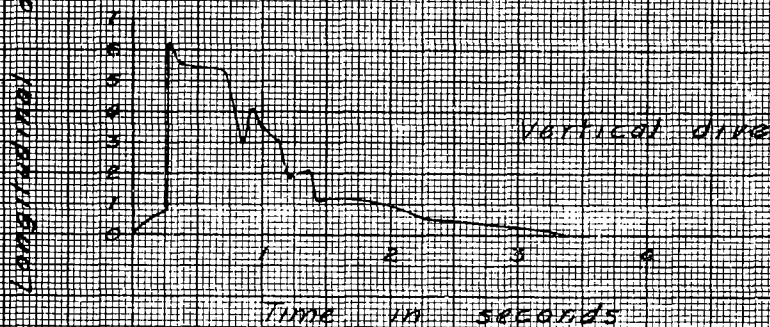
(a) Attitude 15°   Speed 78.2 knots   Flaps 0°

(b) Attitude 15°   Speed 69.5 knots   Flaps 60°

All values are full-scale.

Figure 15.- Time histories of longitudinal decelerations from ditching tests of a 1/5-size model of a Navy SB2C-1 airplane at 13,060 lbs. gross weight. Tests in calm water with simulated damage of bomb-sight doors, bomb-lever doors and bomb bay doors.

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